

Microinverter DC Disconnect Requirements in PV Applications: Interpreting the National Electric Code

INTRODUCTION

The practice of using connectors as a means of DC disconnection in PV systems is widely accepted. This paper discusses DC disconnection requirements under the National Electric Code (NEC) as they apply to microinverters. The means-of-disconnection requirement was established to allow safe equipment servicing. It is not intended as a means of disabling the system under fault conditions.

We will summarize code requirements and outline the code sections that allow connectors to be used as a means of DC disconnect. Please note that this discussion is limited to the **DC** disconnection requirement only. We will quote applicable sections of the code, followed by discussion. The word "code" refers to the National Electric Code (NEC), NFPA70.

CODE SECTIONS

690.13 – "Means shall be provided to disconnect all current-carrying conductors of a photovoltaic power source from all other conductors in a building or other structure."

Discussion: This section establishes the basic requirement for a means of disconnecting conductors to allow for safe equipment servicing. The intent of the requirement is to prevent 1) outside power sources (including the utility) from energizing the PV system wiring, and 2) the PV system from energizing other wiring systems.

Please note that the code specifically requires a means of disconnecting current-carrying conductors "in a building or other structure." This section was written when the only PV inverters on the market were string or central type inverters, which required routing of DC wiring through buildings. The inverter was typically installed in a garage or outside area, and DC wiring had to be run some distance from the rooftop PV array to the inverter.

Today's microinverters are mounted under each module. Therefore, DC wiring no longer needs to be routed into or around buildings. The DC circuit for each module/inverter pair is restricted to the area immediately beneath the associated module.

690.14 -- Additional Provisions.

- (A) Disconnecting Means. The disconnecting means shall not be required to be suitable as service equipment and shall comply with 690.17.
- (B) Equipment. Equipment such as photovoltaic source circuit isolating switches, overcurrent devices, and blocking diodes shall be permitted on the photovoltaic side of the photovoltaic disconnecting means.
- (C) Requirements for Disconnecting Means. Means shall be provided to disconnect all conductors in a building or other structure from the photovoltaic system conductors.
 - (1) Location. The photovoltaic disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.

Exception: Installations that comply with 690.31(E) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.

(D) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations. Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4):

(1) A direct-current photovoltaic disconnecting means shall be mounted within sight of or in the inverter.

(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter.

The requirements in 690.14(D)(1) and (D)(2) provide for servicing disconnects at the inverter.

(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.14(C)(1).

(3) A plaque shall be installed in accordance with 705.10.

Discussion – Section 690.14 addresses DC disconnection requirements. Section 690.31(E) clearly states that the requirements under Section 690.14 are for “Direct-Current Photovoltaic Source and Output Circuits Inside a Building.” The DC conductors in a microinverter installation are not located inside a building; therefore, this section does not apply. However, Section 690.14(D)(1)—which states that the disconnecting means shall be “within sight of or in the inverter”—does apply. A connector attached to the inverter clearly meets this requirement.

690.17 -- Switch or Circuit Breaker.

The disconnecting means for ungrounded conductors shall consist of a manually operable switch(es) or circuit breaker(s) complying with all of the following requirements:

- (1) Located where readily accessible
- (2) Externally operable without exposing the operator to contact with live parts
- (3) Plainly indicating whether in the open or closed position
- (4) Having an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Exception: A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for the use.

Discussion – The exception under Section 690.17 clearly allows the use of a connector as a disconnecting means, provided that it complies with Section 690.33, below.

The term “listed and identified for the use” is ambiguous. Connectors are not listed; rather, they are “recognized components.” “Listed” is defined in the code as, “Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated

standards or has been tested and found suitable for a specified purpose." "Identified for the use" refers to the connector's electrical and environmental ratings.

Recognized components are used in end-product assemblies, becoming part of the listing of the end product. The use of recognized components is controlled by the end-product construction report, along with the follow-up services performed by the listing agency at the manufacturing facility. The word "identified" ("listed and identified for the use") simply means that the product is authorized by an appropriate Nationally Recognized Testing Laboratory (NRTL) and marked as such. OSHA recognizes CSA International, UL, ETL, and TUV, to test PV products under the NRTL program.

690.33 – Connectors

The connectors permitted by Article 690 shall comply with 690.33(A) through (E).

(A) Configuration. The connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises.

(B) Guarding. The connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

(C) Type. The connectors shall be of the latching or locking type. Connectors that are readily accessible and that are used in circuits operating at over 30 volts, nominal, maximum system voltage for dc circuits, or 30 volts for ac circuits, shall require a tool for opening.

(D) Grounding Member. The grounding member shall be the first to make and the last to break contact with the mating connector.

(E) Interruption of Circuit. Connectors shall be either (1) or (2):

The two options provided for connectors in this requirement provide for safe disconnection of circuit connectors either by being able to be opened under load or by having a warning indicating that disconnection prior to opening the connector is necessary.

(1) Be rated for interrupting current without hazard to the operator.

(2) Be a type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting."

Connectors that can be opened or disconnected using only the hands are not acceptable.

Discussion – The requirements in Section 690.33 establish:

- a) the need for a unique, noninterchangeable connector that cannot be connected to the wrong circuit
- b) the connector to be constructed to prevent risk of accidental shock
- c) that the connector be latching or locking

The code CLEARLY allows the use of connectors as a means of disconnection, but this does not mean that the connectors must be listed as disconnect switches. In fact, the requirement for a connector that CANNOT be disconnected under load implicitly eliminates rating the connector as a disconnect switch. Moreover, no connectors are listed as disconnect switches, and no testing standard exists for such listing. Per NEC 90.4, the Authority Having Jurisdiction (AHJ) is empowered to allow connectors as disconnect switches.

Microinverter installations have greater safety in terms of fire and shock risk than string inverters. DC voltages in microinverter systems are typically less than 50VDC,

while installation voltages of up to 600VDC are common for conventional string/central inverters. Moreover, the DC wiring remains under the PV module and is not routed through buildings or structures.

The Section 690.33 requirements were changed slightly between the 2005 and 2008 code. An additional code provision requires that "connectors shall be of the latching or locking type," requiring a tool to open if they are not rated for load-break operation. The connector must be certified and identified for the use (the code says "listed," but, as previously discussed, connectors are "recognized components," not "listed"). This means that the connector must be rated for the voltage, current, and environmental conditions under which it will be used.

The DC connector used on the M190 and M210 Microinverters is rated for 600VDC, 30 amps, outdoor use. The M190 and M210 use two versions of the MC connector.

The MC3 connector meets the requirements of the 2005 NEC, which does not require a locking type connector or a tool to open the connector. The MC3 is a latching connector, but it does not lock and does not require a tool to disconnect. It is not rated for load-break and is labeled, "Do not disconnect under load."

The MC4 connector meets the requirements of the 2008 NEC. It is a locking type connector, requiring a tool to open. It is rated for load-break when used with the Enphase Microinverter, although it is labeled "Do not disconnect under load."

CONCLUSION

The National Electric Code allows connectors to be used as a means of disconnection for the microinverter DC circuits. The Multi Contact MC3 and MC4 connectors meet 2005 NEC requirements. The MC4 connector meets 2008 NEC requirements, as do connectors made by several other manufacturers.

Enphase has taken the initiative to obtain CSA certification of DC connectors as a means of disconnection. The connectors, when used with the Enphase Microinverter, are approved for load-break operation under Section 690.33(E)(1).